U. S. NAVAL SUBMARINE MEDICAL CENTER

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THE RESPONSE ANALYSIS TESTER (RATER)
AND LOGICAL INFERENCE TESTER (LOGIT):
I. Some Preliminary Findings

by

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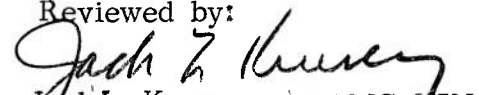I. Some Preliminary Findings

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SUBMARINE MEDICAL RESEARCH LABORATORY
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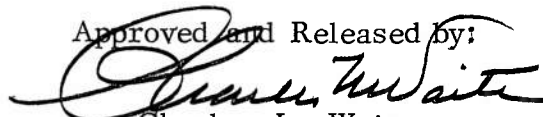Research Work Unit MF022.03.03-9023.11

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SUMMARY PAGE

THE PROBLEM

To establish preliminary, normative data for Navy enlisted men
on the Response Analysis Tester (RATER) and Logical Inference Tester
(LOGIT) performance testing devices.

FINDINGS

Based on a sample of 74 Navy enlisted men, scores are presented
for RATER and show that differentiation among subjects is possible.
Also, RATER scores are related ($p < 0.05$) to the MECH portion of the
Basic Test Battery. Results with LOGIT showed it to be readily
learned and that a baseline of performance is established after 8-15
problems.

APPLICATIONS

The data presented in this report and experience with RATER and
LOGIT have shown them to have wide applicability in the performance
measurement field, —RATER as a vigilance testing instrument and for
the detecting of performance decrements of a visual-motor nature.
LOGIT has applicability in longitudinal studies designed to detect
decrement in higher mental processes including problem solving and
logical thinking. Other uses for operational use are suggested.

ABSTRACT

This report presents preliminary findings obtained with the RATER and LOGIT performance testing devices. For RATER the distribution of corrected scores is presented along with the product moment correlations between RATER scores and Navy Basic Test Battery scores for 74 Navy enlisted Submarine School students. RATER measures complex reaction time and as such, may be an excellent vigilance testing device for detecting performance decrements of a visual-motor nature. LOGIT on the other hand, presumably taps more complex cognitive processes and may be a valuable tool for use in longitudinal studies where the effects may be quite subtle and not otherwise identifiable. Data are presented for four subjects who solved from 25 to 36 problems each. From the curves, the effects of initial learning and problem-solving technique are readily seen. The results also show that leveling-off in performance occurs after 8 to 15 problems. Further work is suggested and examples of operational uses of the instruments are set forth.

THE RESPONSE ANALYSIS TESTER (RATER) AND
LOGICAL INFERENCE TEST (LOGIT):
I. SOME PRELIMINARY FINDINGS

INTRODUCTION

This is a preliminary report on the results obtained with the RATER and LOGIT performance testing instruments currently in use in the Personnel Research Branch. RATER and LOGIT are acronyms for Response Analysis Tester and Logical Inference Tester. These instruments were developed by Dr. R. S. French at General Dynamics Convair. Advances in aerospace, marine and submarine technology have added emphasis to the problem of assessing human performance efficiency under stress. Establishing baseline proficiency in psychomotor skills through repeated measurement obtained from equivalent problems, and monitoring these skills over an extended period, pose a number of special problems which have been under investigation for the past several years. As a result, RATER and LOGIT were developed as compact, portable devices possessing most of the features required by these specialized measurement conditions. Promising applications for RATER and LOGIT include the study of drug effects, aging and special environmental stresses such as the rotating room, pressure chamber and SEALAB. Equally promising are possibilities of experimentation in the areas of learning and retention, transfer of training, logical inference, small group processes and decision making.

As a precursor to any experimentation involving RATER and LOGIT, it is necessary to generate a volume of normative data collected from a variety of population samples performing under different, controlled conditions. The characteristics of the score distributions themselves and the covariance patterns with measures of other related measures, give insight into the problems of validity and reliability. In brief, therefore, the objectives of this study were to present preliminary normative data for several scores obtained from the administration of RATER and LOGIT to Navy enlisted men.

Initial validation studies on RATER and LOGIT have been accomplished in the Convair Human Engineering laboratories and at the U.S. Naval School of Aviation Medicine, Pensacola, Florida, through a cooperative research program. Also, the prototype LOGIT was utilized in a joint research project between the Navy and the National Institutes of Health (French, 1965a, and Piatt and French, 1963). It is hoped that as more of these instruments are put to use in the various laboratories, a cooperative exchange of information can be established so as to make available normative and validity data to all users.

DESCRIPTION OF THE INSTRUMENTS

RATER presents a simple choice reaction time situation in which the subject is required to match a response key to each of four stimuli (geometric symbols or colors) appearing in a display window. The sequence of stimuli, generated through solid-state circuitry, is an infinite (non-repeating) random series. The subject's performance, scored in terms of speed and accuracy, is recorded directly on counters or may be recorded on chart paper for detailed analysis or error and latency data. The device may be operated in either a self-paced mode or an auto-paced mode with experimenter control over the rate of stimulus presentation varying from 0.5 to 2.0 seconds per symbol. In addition, the correspondence between symbol and correct response key may be varied systematically to study habit interference, or as a means of increasing task complexity, often desirable for certain kinds of experimentation. The subject console is pictured in Figure 1.

Figure 1 - RATER Subject Console.

LOGIT is a device measuring higher mental processes such as reasoning, memory and decision-making. The task for the subject is to learn, with a minimum of button presses, the random order in which twenty buttons in a four-by-five matrix should be pressed, as established for a specific problem. Figure 2 shows the subject console. Learning is accomplished through an application of memory and a system of deductive logic which is common to all LOGIT problems, and which is explained to the subject prior to the onset of the task. A standard set of 5,000 problems (French, 1965b), classified in terms of the minimum number of moves required for solution, has been developed by computer for the instrument. These problems are quickly set into the device by means of a switch panel on the back of the control console.

Figure 2 - LOGIT Subject Console

TEST PROCEDURE

For both instruments the subject was seated in a straight backed chair in an air-conditioned room with the subject console placed in front of him on a small table 26 inches high. Communication between the experimenter and the subject was by means of an intercom system.

RATER

The stimuli reported in this study were four colors, green, yellow, red and blue. After a short briefing on the purpose of the study, each subject was given a five-minute practice trial in the self-paced mode to facilitate learning the stimulus-response key relationship. This was followed by two five-minute trials in the auto-paced mode with a presentation rate of one color per second. The results here were taken from a third five-minute, auto-paced trial so as to rule out any practice effects. Two minute rest periods separated the trials. Performance was scored by subtracting the total number of errors from the total number of correct responses. Thus, a perfect score in the one per second presentation rate would be 300. In addition, errors of omission and commission were obtained. The subjects were told in the instructions that they would be penalized for errors.

LOGIT

Prior to being given the first problem, the subject was given a detailed explanation of the procedure to be used in solving the problems. These instructions are presented in Appendix A. The experimenter demonstrated the procedure as well. Once the subject felt that he had the instructions well in mind, the experimenter left and the problem solving began. The progress of the subject in solving the problems was monitored on the control console where the order is automatically transformed into the correct ordinal position. At the conclusion of each of the first two or three problems the method of attack was discussed with the subject depending on the progress made in solving the problem. Problems were presented on successive days at random times during the day, so as to not inconvenience the subject. After the first two or three problems, there was no communication between the experimenter and the subject during the progress of the problem-solving. The subjects were informed of their scores at the conclusion of each problem so as to give some feed-back and enhance motivation. After the initial learning trials, the subjects were given fifteen minutes in which to learn the correct sequence. The criterion for learning was two errorless trials in succession. The session was concluded upon learning to criterion, five trials, or fifteen minutes whichever occurs first. The score was the number of errors made over the entire session. The score is based on the problem index for the problem and is the

minimum number of trials required for completion, and ranges from 64 to 172. The problem index for the first trial is that given for the particular problem. For succeeding trials, the index is 20 since it is possible for a subject correctly to press the buttons after the first trial.

<div align="center">RESULTS</div>

RATER

Figure 3 contains a frequency distribution obtained in a preliminary study with RATER. The subjects were 74 Navy enlisted men whose mean age was twenty years. These men were awaiting Submarine School and were randomly picked by the barracks master-at-arms. It is readily seen that the distribution of scores is negatively skewed, the mean being 189.5, and the standard deviation, 90.4.

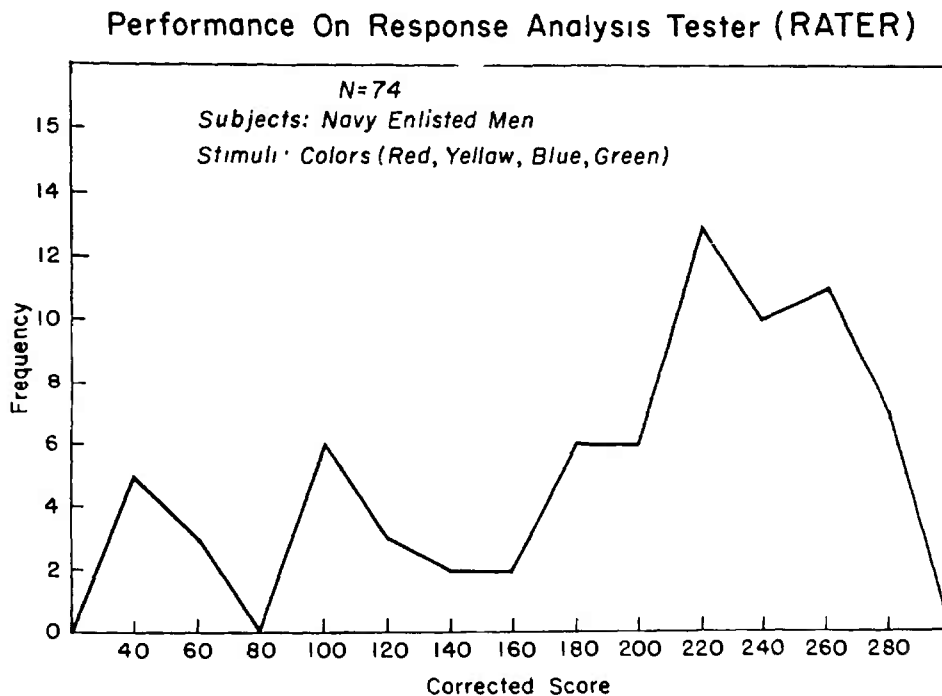### Performance On Response Analysis Tester (RATER)

Figure 3

Eleven of the subjects had total error scores greater than 100 which is indicative of possible low motivation as well as poor performance. If the scores for these men are eliminated from the data, the distribution becomes less skewed with the mean approaching 200 responses. None of the subjects reported any difficulty in understanding the instructions or in operating the subject console. The mean GCT of the subjects was 59 (80th percentile for the Navy-wide population), indicating that the subjects were above average in intelligence. Since Basic Test Battery scores were available on nearly all the subjects, product-moment correlations were computed for RATER scores with each of the aptitude test scores with the following results:

GCT	ARI	MECH	CLER
0.19	0.02	0.35	-0.05

Only one coefficient reached significance at a satisfactory confidence level (5 per cent), namely the correlation with MECH. One plausible explanation for this relationship is that those men who have higher mechanical aptitude, as measured by the test, probably feel more "at home" with a piece of apparatus such as the RATER subject console. Also, this might be due to a speed or general alertness factor which would likely exist in the auto-paced mode. The subject, on the whole, did tend to get somewhat higher scores in the self-paced mode, possibly because this procedure allows for "ad-lib" pauses which may be used by the subject to reconnoiter the situation, thereby conceivably enhancing the learning process.

No reliability data are available either in the literature or from this study. However, a few subjects were tested a second time several days after the first session, and their scores appeared to be in the same general range as that achieved in the first session.

LOGIT

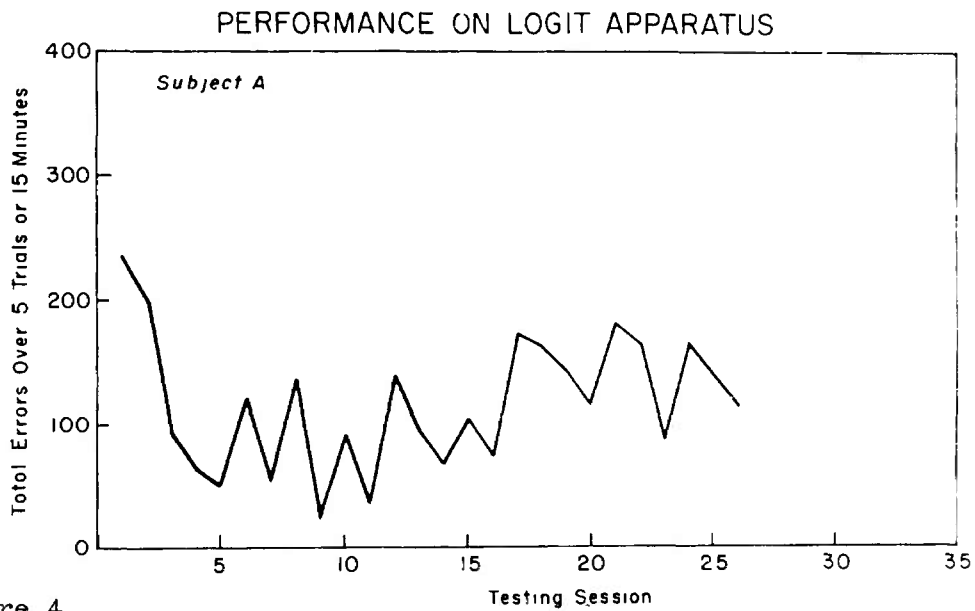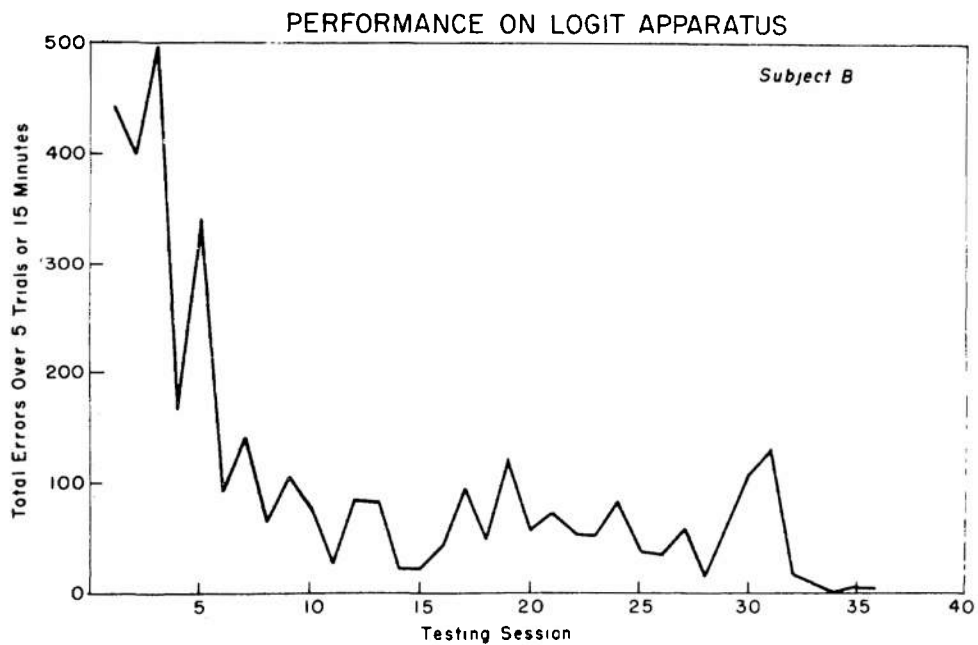The results obtained with LOGIT are presented in Figures 4, 5, 6 and 7.

PERFORMANCE ON LOGIT APPARATUS

Figure 4

PERFORMANCE ON LOGIT APPARATUS

Figure 5

PERFORMANCE ON LOGIT APPARATUS

Subject C

Figure 6

PERFORMANCE ON LOGIT APPARATUS

Subject D
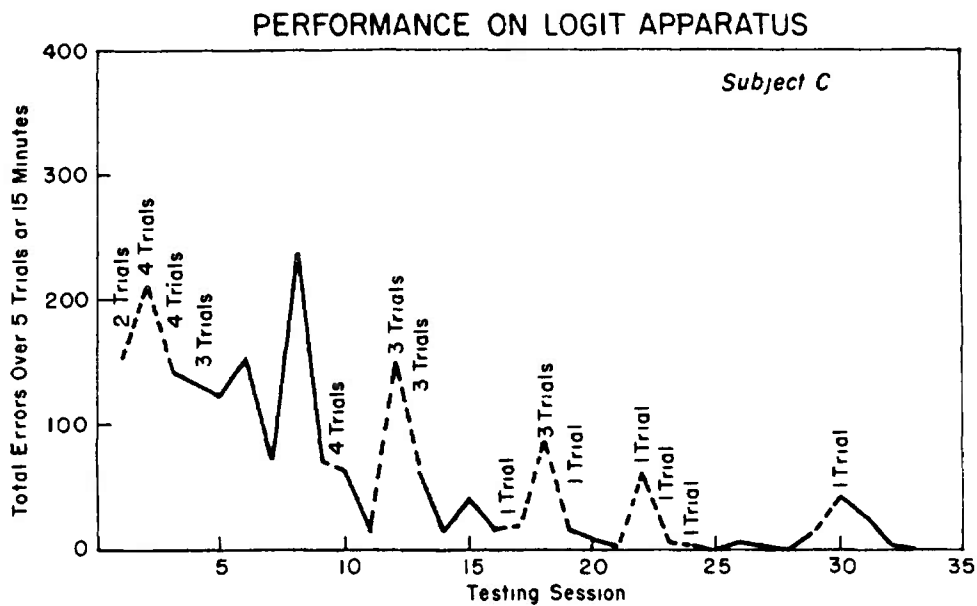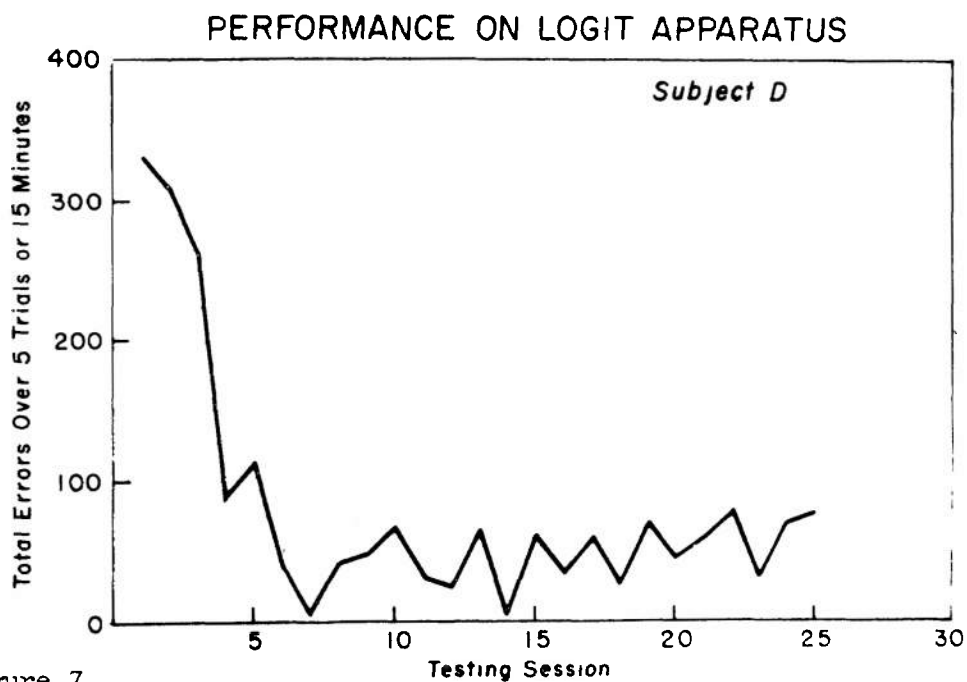

Figure 7

The subjects were all SMRL personnel, two civilians and two Navy enlisted men. All four subjects were given the same sequence of problems. That is, for a given testing session each subject was given the same problem which, of course, need not have been given on the same day. All four were keenly interested in the apparatus and were most willing subjects whose motivation continued at a high level throughout the series of problems. As would be expected, individual differences were quite apparent in the results obtained. The effects of initial learning and the establishment of a problem-solving technique are evident. Our results agree with those of French(1965a) in that it takes between eight and fifteen problems before a leveling off occurs. All performance curves show a "roller coaster" effect, that is, a daily up and down variation in scores. While this might be explained away as the result of the daily variation in mood and motivation, this is not offered as a cause since the subjects, well known to the experimenter, always were eager to tackle a new problem and better their previous scores. A more plausible explanation might be that even though the problems are equated for Problem Index--the minimum number of button presses required for completion,--they are not of equal difficulty due to patterning cues and the like. In certain problems the sequence turns out to be a diagonal for four or five buttons; in others, the corners, and so on. Since there are no data available at the present time which would answer this question it must be left to conjecture. All four subjects reported that they felt that certain problems were easier than others, even though they had the same problem index. With data available on only four subjects it was not feasible to attempt an analysis based on difficulty level at this time.

It may be recalled that the scores presented are the sum of errors, or incorrect button presses made in the fifteen minutes allotted. With the exception of Subject C, all subjects were able to make five trials at solving the problems in fifteen minutes. The criterion for learning the sequence is the completion of two, successive, errorless trials. Subject C was a very careful person who contemplated every move and who rehearsed the partial sequence many times before proceeding. As indicated in Figure 5, Subject C was unique among the four subjects in that the time limit was reached (15 minutes) a number of times before the criterion of two errorless solutions was attained. In those sessions where less than five trials were made in the allotted time, it has been noted on the graph. On the other hand, subjects B and D (Figures 4 and 6) demonstrated a rather typical learning curve with rapid error reduction (learning) occurring during the first eight to ten trials, and a tendency to level off in subsequent sessions. Subject D has been carried beyond what is shown in Figure 7, and his LOGIT scores have remained at about the same level through over fifty problems.

SUMMARY AND CONCLUSIONS

This report has presented preliminary findings obtained at the Submarine Medical Research Laboratory with the RATER and LOGIT performance testing device. These results suggest that RATER and LOGIT may be valuable tools to be added to the performance testing "kit". Upon validation, it may turn out that these scores may be "tapping" unique aspects of behavior. RATER, for example, measures complex reaction time and as such, may be an excellent vigilance testing device for detecting performance decrements of a visual-motor nature. LOGIT, on the other hand, presumably taps more complex cognitive processes and as such, may be a valuable tool for use in longitudinal studies where the effects may be quite subtle and not otherwise identifiable. Observations of subjects solving a LOGIT problem suggests that the task constitutes a real challenge and, as a result, provides intrinsic motivation over many trials.

A number of studies involving RATER and LOGIT are envisaged. Both instruments are currently being used in a number of situations by other laboratories such as the Naval Aviation Medical Center and their Air Force counterparts. It seems feasible that they might become the standard tests for use in performance testing in unusual environments. In this context, both techniques appear to have immediate application to the man-in-the-sea program and related studies. It should be remembered, however, that the results presented here are only preliminary and caution should be exercised in generalizing to other testing conditions and subject samples.

Reliability studies are currently underway at SMRL. Re-test estimates of reliability based on liberal subject sampling as well as autocorrelational approaches are being utilized as a means of ascertaining the amount and the conditions surrounding the occurrence of measurement error intrinsic to the two measures. Typical research problems which may be considered are: The identification of mechanisms by which problems weighted in spatial memory are solved, trait patterns as well as indices of emotionality (e.g., autonomic nervous system indices) characterizing good and poor "performers" on LOGIT and the transfer effect of LOGIT training on the ability to solve tactical problems such as torpedo approach and attack. Hopefully, future subjects pretrained on these devices can be used in studies aimed at isolating the effects of exposure to confinement, hyperbaric atmospheres, exotic gas mixtures and other variables common to man's venture into inner and outer space.

APPENDIX A

Subject Instructions for LOGIT

"LOGIT is a test of your logical reasoning and memory skills.
The object of the test is to learn the correct, pre-set order for
pressing the 20 buttons on the panel in front of you, and to do this
in as few button presses as possible. Read the instructions carefully
and then ask the Test Administrator to demonstrate the correct proce-
dure. If there is anything you do not understand, discuss the matter
with the Test Administrator until you are entirely satisfied.

"To solve a LOGIT problem, begin by pressing Button No. 1 in the
upper left-hand corner. Note that the button "lights up" or comes ON.
Now, press No. 2. If No. 1 goes OUT, this tells you that in the cor-
rect, pre-set order that you are to learn, No. 2 should be pressed
before No. 1. On the other hand, if No. 1 remains ON, you now know
that No. 2 should be pressed after No. 1. Repress No. 1 if it goes
OUT. Now, press No. 3. If both No. 1 and No. 2 go OUT, again, you
know that No. 3 should be pressed before either of them. Repress
them in the order 2-1, which you know to be correct. Before pro-
ceeding on to No. 4, remember that your task is to learn the correct
order. To do this you must start memorizing the correct sequence from
the very beginning or you will become confused as the sequence gets
longer. Repeat out loud the order "3-2-1, 3-2-1" (or whatever the
correct order is) several times, touching your finger lightly to the
buttons. Do not repress any buttons that are ON, however, since this
will add to your total error score. When you are sure you have the
correct order fixed in memory, press No. 4, to learn where it falls
in the sequence, and proceed as above. Continue to add new buttons,
one at a time, in this manner until you have progressed over the whole
panel from 1 through 20.

"The principle illustrated above applies to any button on the
panel. When any given button is pressed, all of the buttons that go
OUT should be pressed subsequently in the correct pre-set order, while
those that remain ON should be pressed prior. Actually, the task has
been structured so that you are not ordinarily aware that you are
applying this principle. In summary, this is your task:

"Proceed from left to right across each row from the top of the
panel to the bottom. Add the next button to the series only after you
have successfully repressed all preceding buttons that go OUT, and
have memorized the correct order up to that point. Always repeat any
buttons that go OUT in the order you have learned is correct. Each
of the preceding buttons should come ON when it is repeated. If any

go OUT, your memory of the order must be incorrect. Be sure to correct your memory "image" and repress the buttons in the correct order before proceeding.

"Immediately after you press each new button, rehearse the sequence of lights remaining ON by running your finger over the correct button sequence lightly without repressing the buttons. Mentally "insert" the new button at this point before you verify the remainder of the sequence by repressing the buttons that were turned OFF. Note that you are in effect constructing a mental "image" of the correct order, one unit at a time, inserting each new button in the correct ordinal position based upon the information you obtain from the panel.

"When all of the lights on the panel are finally ON, the panel will automatically clear itself, thus completing the trial. All of the information you need to establish the correct order has been revealed. If you have been able to follow the procedure without error (extra button presses), you will have pressed a total number of buttons (varying from 64 to 172) which defines the score for a perfect solution. This perfect score, or Problem Index, is known for 5,000 different LOGIT problems, based on information provided by a digital computer. Your error score on the first trial is equal to the number of button presses in excess of the Problem Index for this given problem.

"After you have completed the first trial, the Test Administrator will record your score, clear the panel, and present the same problem to you again. On the second and subsequent trials, you should proceed somewhat differently. Since you now (ideally) have learned the correct order, you should press the buttons in this order, rather than proceeding systematically from the top of the panel as you did on the first trial. On the second and subsequent trials with the same problem, each button press in excess of 20 will count as an error. In case you did not learn all of the sequence on the first trial, you may, of course, build up the sequence systematically as before, although this will cause you to press many more than 20 buttons. You will be given a maximum of five trials on each problem. Try to press as few buttons as you can on these five trials, following the procedure exactly as outlined.

"Begin the test when the Test Light comes ON. When you complete a trial the Test Light will go OUT. Watch for the Ready Light indicating that a new trial is about to begin. Do not press any button which is already ON. Use one hand and one finger, only. If you press more than one button at a time the test will be terminated automatically. Work as rapidly as you can without becoming confused since the total amount of time you will be allowed on each problem is 15 minutes. Now ask for a demonstration."

REFERENCES

1. French, R.S. RATER and LOGIT: Devices for assessing human performance efficiency. General Dynamics Convair Report No. GD/C-DBD-65-130, 21 June 1965(a).

2. French, R.S. LOGIT: Standard problems. General Dynamics Convair Report No. GD/C-DBD-65-038, 31 August 1965(b).

3. French, R.S. RATER and LOGIT: Model 1: Operation and maintenance instructions, Second revision. General Dynamics Convair Report No. GD/C-DBD-65-027-2, 15 September 1966.

4. Piatt, J.L., Jr., & French, R.S. Evaluation of RATER and LOGIT. General Dynamics/Astronautics Report No. GD/A 63-1348, 18 December 1963.

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13 ABSTRACT

This report presents the results of preliminary work with two performance testing devices. One (RATER) measures choice reaction time or the time required to respond to four different colored lights presented in random order for five minutes by pressing the corresponding correct button. The other device (LOGIT) measures the ability to solve problems concerned with determining the correct sequential order in which twenty buttons are pressed in order to light the board. Data are presented for comparing the scores for any group tested on the RATER with a typical Navy population. Results with LOGIT show it to be potentially useful for determining performance decrements during exposure to unusual environments, such as high pressure, confinement, or Helium-oxygen breathing mixtures.

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14 KEY WORDS	LINK A		LINK B		LINK C	
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Measurement of performance of personnel						
Performance decrement, device for measuring						
RATER and LOGIT						